IEA-Bioenergy Task39
Tuesday, 09. September 2008

"Application of Bioethanol Blends in a Motor Vehicle"

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1. Introduction

2. Properties of Ethanol-Blends

3. Test Bench Investigation
   - Cold Start Ability
   - Influence on Emissions

4. Outlook and Summary

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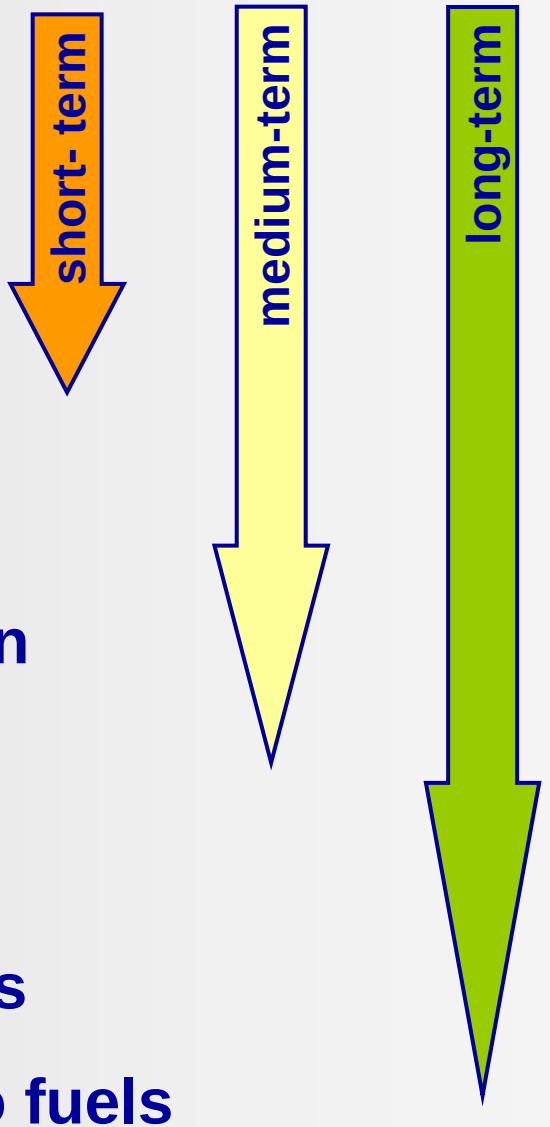
- Stretching of fossil oil reserves
- EU directive 2003 / 30 / EG
- Alternative liquid fuel

  → Use existing infrastructure

- Realizing new / alternative combustion processes and engine concepts
- Independence of fossil energy carriers
- Substantial CO_2-minimization with bio fuels



Motivation for Alternative Fuels

Category 1: **up to 10% ethanol share**

⇨ **No adapted engine control unit (ECU) necessary**

Category 2: **up to 85% ethanol share**

⇨ **Flexible Fuel Vehicles (FFVs)**

⇨ **Adapted ECU (air-fuel ratio, Ignition timeing, ...)**

Category 3: **up to 100% ethanol**

⇨ **Modern direct injection combustion process**

⇨ **High charging / downsizing favorable**

Use of Bioethanol in Vehicles

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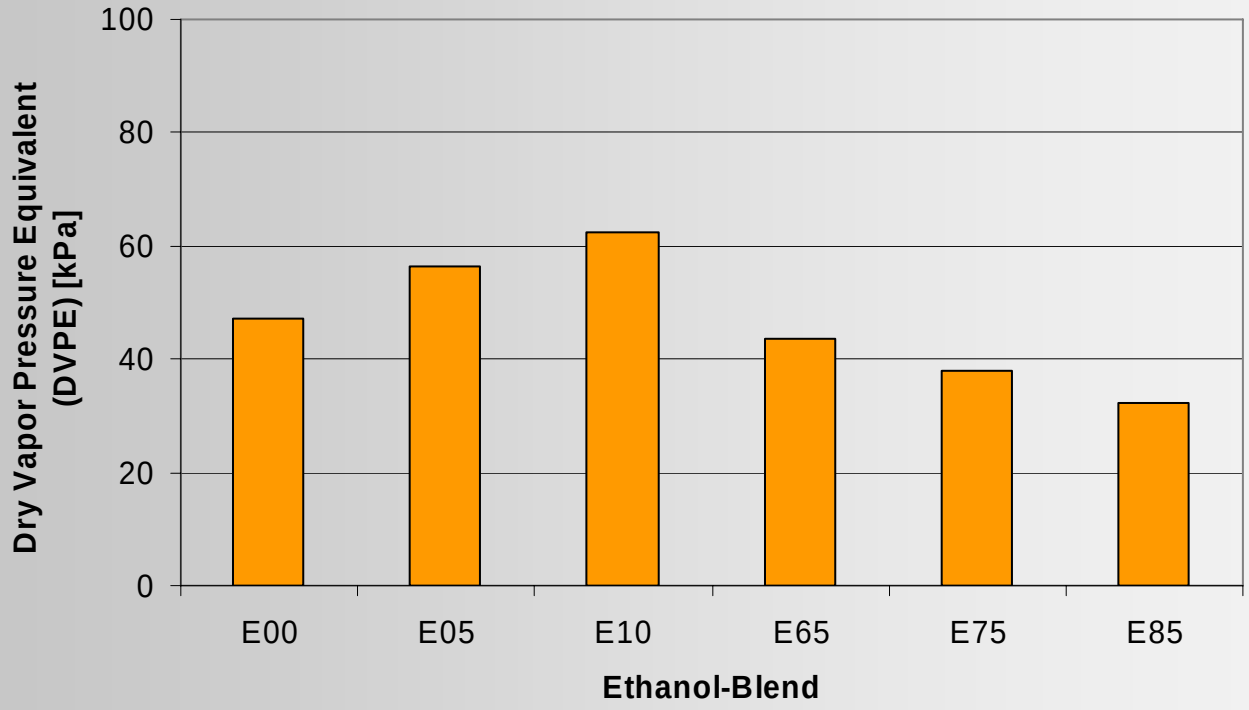
⇨Fuel Blends up to a mixture of 85% Ethanol

		E00	E05	E10	E65	E75	E85
Density by 15°C	kg/m³	753,2	753,8	754,2	778,4	782,9	787,2
DVPE	kPa	47,2	56,3	62,5	43,5	38,0	32,3
RON		95,9	97,4	98,8	106,3	106,8	107,2
Lower Heating Value	MJ/kg	42,1	41,4	40,7	30,9	30,5	29,9
C-Fraction	%M	86,3	84,6	82,2	63,8	60,5	57,0
H-Fraction	%M	13,1	12,7	12,9	13,4	13,7	13,1
O-Fraction	%M	0,5	2,1	5,7	23,2	25	28,8

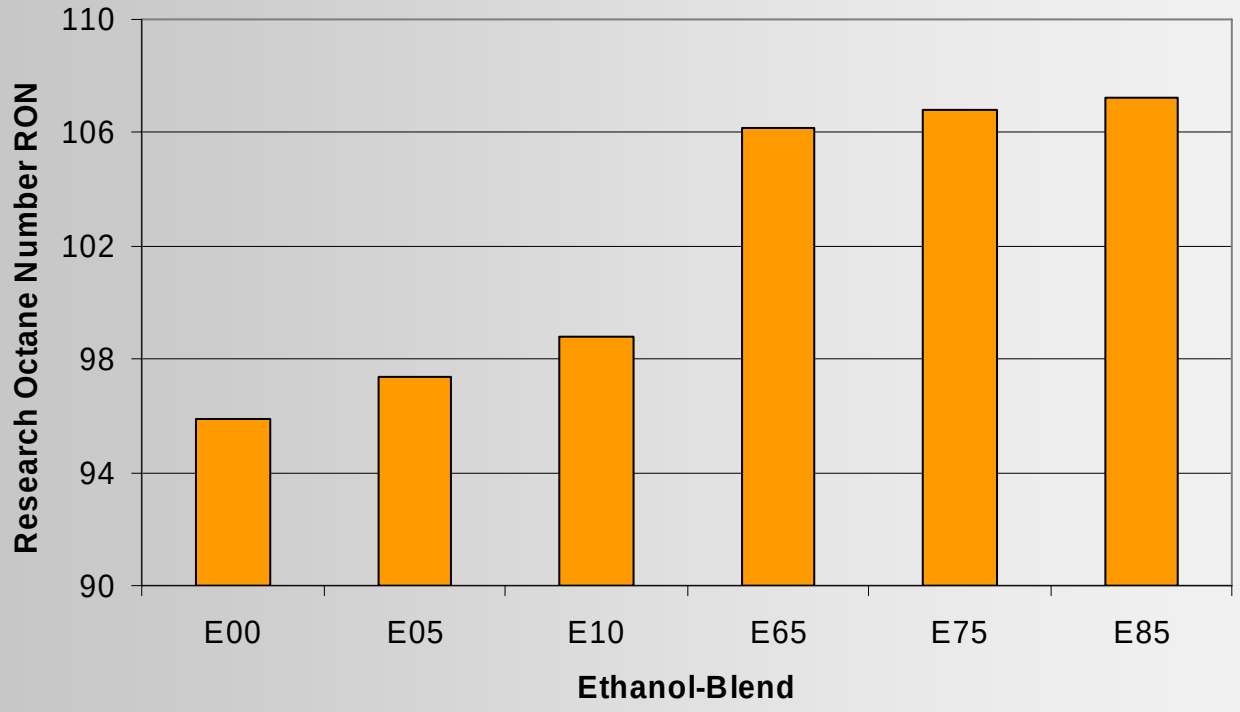
Investigated Ethanol-Blends

⇨ Parameter for the Cold Start Ability



Because of the lower DVPE of Ethanol results problems during the cold start, especially at temperatures below 0°C.

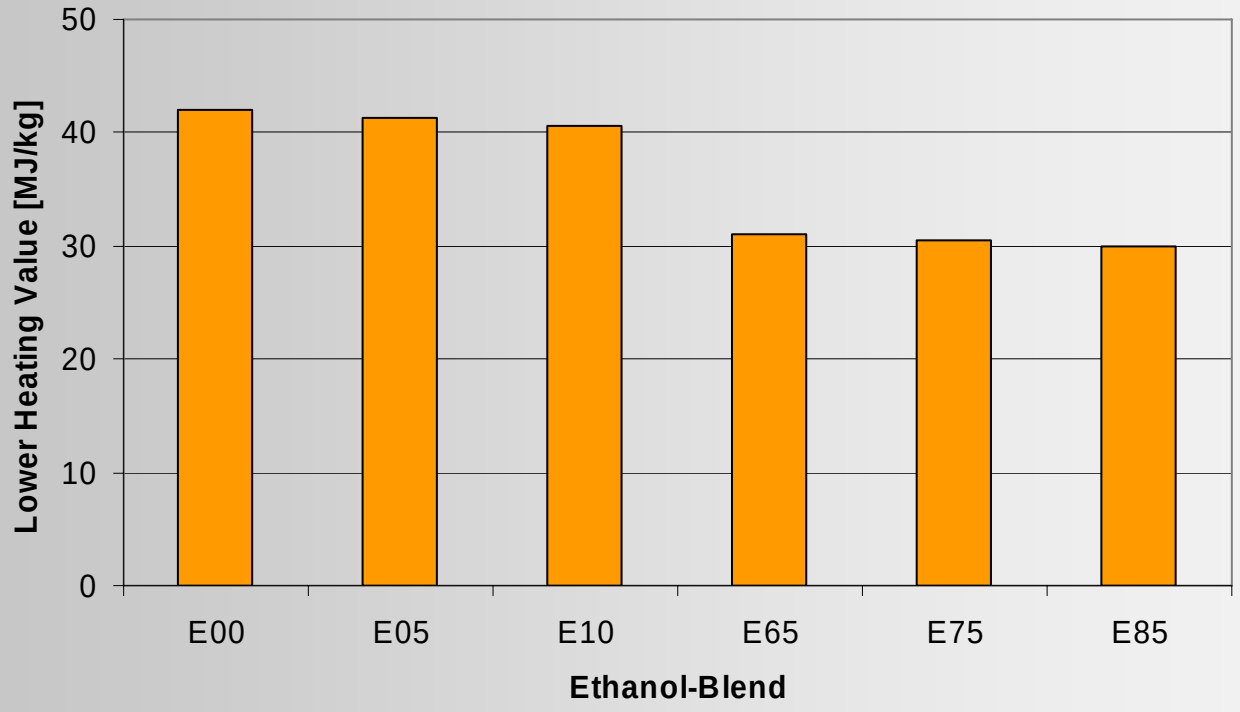
⇨Parameter for the Efficiency



Due to the higher RON of Ethanol it is possible to increase the compression ratio by what the thermal efficiency is also increased. With conventional fuel this is not possible because of knocking combustion.

Research Octane Number (RON)

⇨Parameter for the volumetric Fuel Consumption



Mixtures with Ethanol:

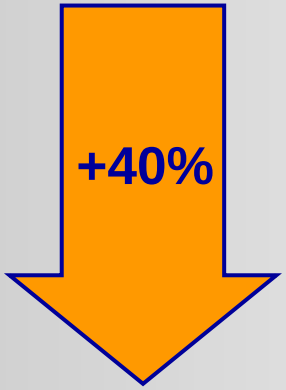
- **Heating value ↓, C-Fraction ↓,O-Fraction ↑**
- **Volumetric fuel consumption ↑**
- **CO_2-emission ↔**

Heating Value

⇨Volumetric Fuel Consumption – CO_2-Emission

Corresponding volumetric fuel consumption for a CO_2-Emission of 140 g/km:

- **Result for E00: 5,9 l/100km**



- **Result for E85: 8,4 l/100km**

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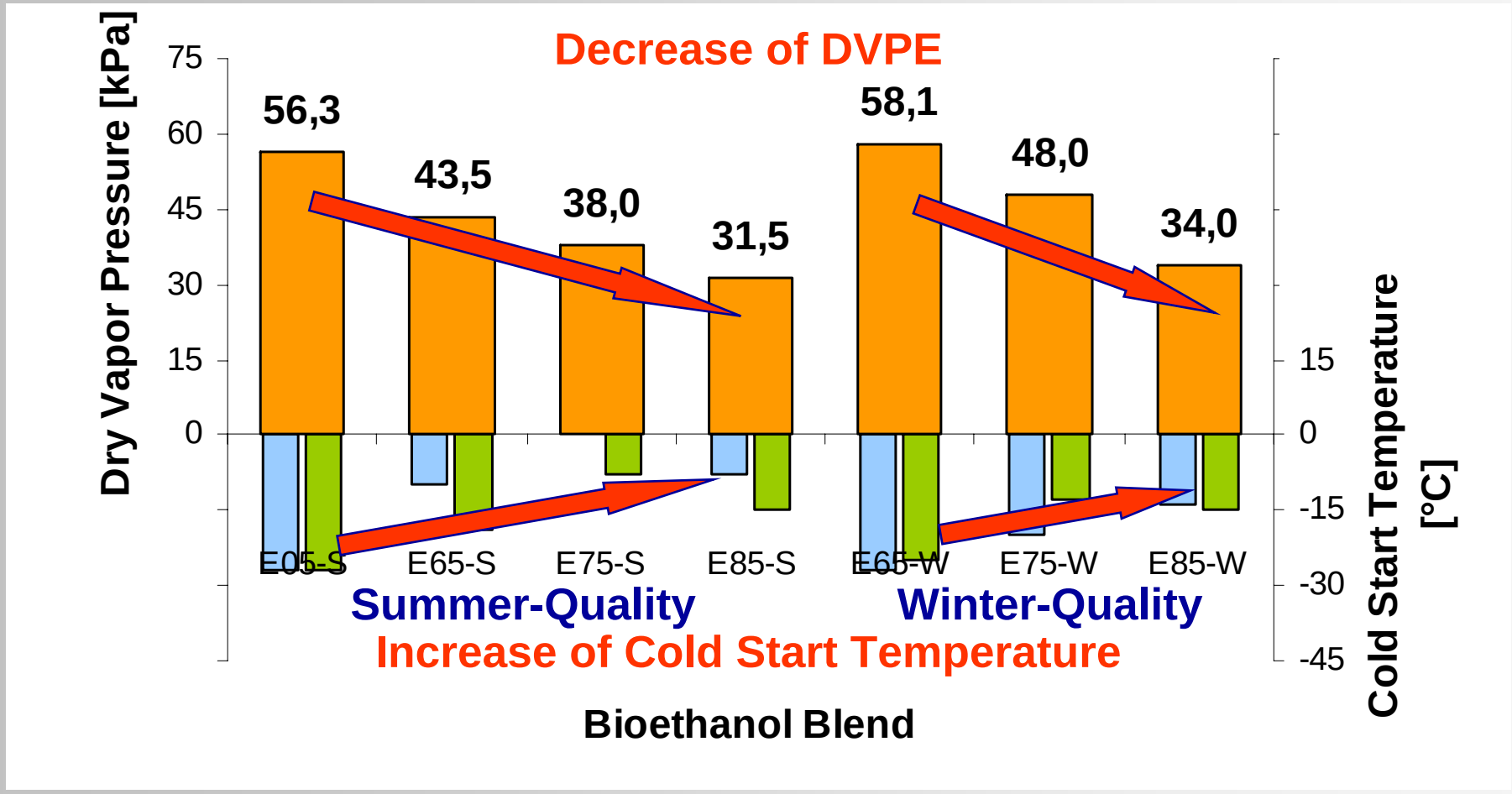
⇨ Vapor Pressure (DVPE) - Cold Start Ability

→ deepest possible temperature for a cold start



Results - Cold Start Ability

⇨Vapor Pressure (DVPE) - Cold Start Ability

→ deepest possible temperature for a cold start

		E05-S	E65-W	E75-W	E65-S	E85-W	E85-S
DVPE	kPa	56,3	56,6	49,1	42,0	42,0	31,5
Vehicle 1	°C	-27	-27	-20	-10	-14	-8
Vehicle 2	°C	-27	-25	-13	-19	-15	-15

As a result the E65 winter fuel (56,6kPa) reaches the same possible cold start temperature of -27°C as the E05 summer fuel (56,3kPa).

⇨ Standard EN 228 for conventional fuels

Characteristic	Unit	Limit	
		Summer-Quality	Winter-Quality
Dry Vapor Pressure (DVPE)	**kPa, min.**	**45**	**60**
	kPa, max.	60	90

⇨ Standard ÖNORM C1114 for Ethanol fuels

Characteristic	Unit	Limit	
		Summer-Quality	Winter-Quality
Ethanol	**% (V/V), min.**	**75**	**65**
	% (V/V), max.	**85**	**75**
Dry Vapor Pressure (DVPE)	**kPa, min.**	**35**	**50**
	kPa, max.	60	90

Fuel Standards

- The results of the measurements verify the direct correlation between the lowest possible temperature for a successful cold start and the DVPE of the investigated ethanol-blends.

- The definition of winter- and summer-E85 in the corresponding Ethanol fuel standard ensure the operation of the vehicle under all typical climatic conditions of central Europe.

Conclusion - Cold Start Ability

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⇨ **Driving Cycles**

New European Driving Cycle

- **NEDC TYP 1 (cold start 20°C)**
- **NEDC TYP 6 (cold start -7°C)**

ARTEMIS program

- **CADC (urban / road / motorway)**

⇨ **Investigated Ethanol Blends**

- **E05 (conventional vehicles und FFV)**
- **E10 (conventional vehicles)**
- **E85 (FFV)**

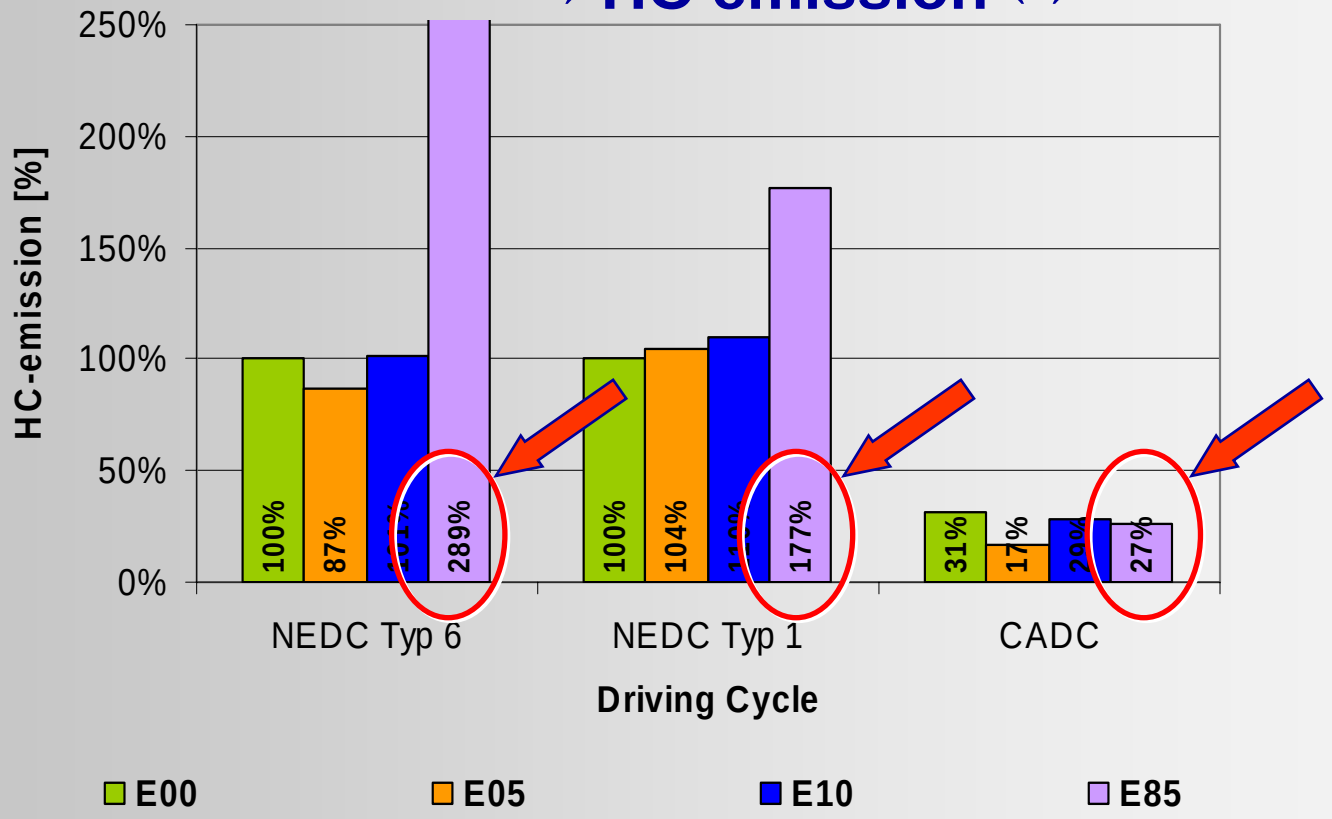
Emission Test

⇨ **Driving cycles with cold start (NEDC)**

→ **HC emission ↑**

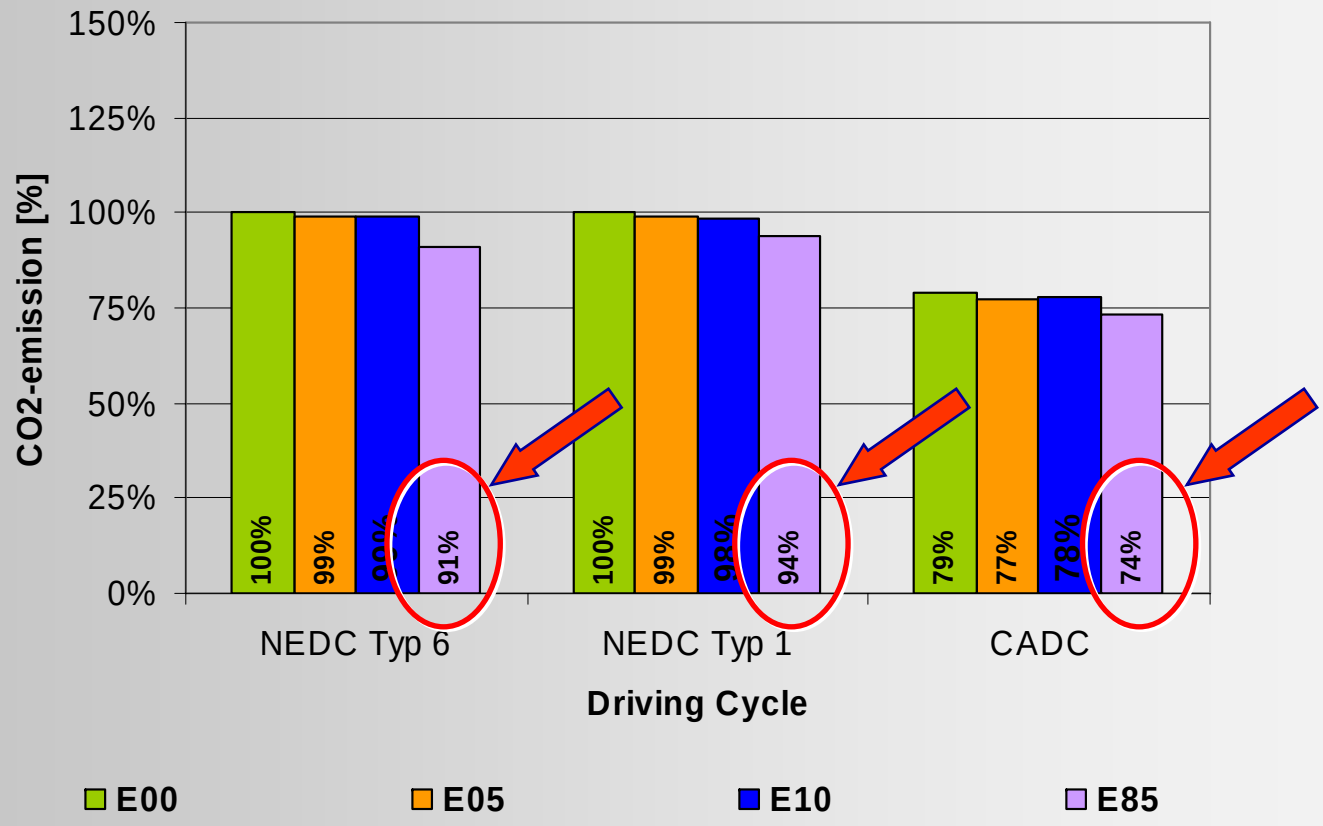
⇨ **Driving cycles with warm start (CADC)**

→ **HC emission ↔**



HC - Emissions

⇨ **For fuel mixtures with 85% Ethanol the CO_2-Emission decreases in all driving cycles. (e.g. NEDC -6% vehicle out CO_2-Emission)**



CO2 - Emission

- For mixtures with up to 10% Ethanol there are hardly any influences on the emission behavior of the vehicle for all investigated driving cycles.
- The cold start at 20°C does not cause any problems for all used mixtures with up to 85% Ethanol.
- Mixtures with 85% Ethanol lead to critical cold start behavior at -7°C and cause an increase of HC-emissions. This behavior could be improved by the use of a winter-E85-Fuel (lower amount of Ethanol, adapted DVPE)
- The vehicle out CO_2-emission in the New European Driving Cycle can be reduced for up to 6% by the use of E85.

Conclusion – Emission Test

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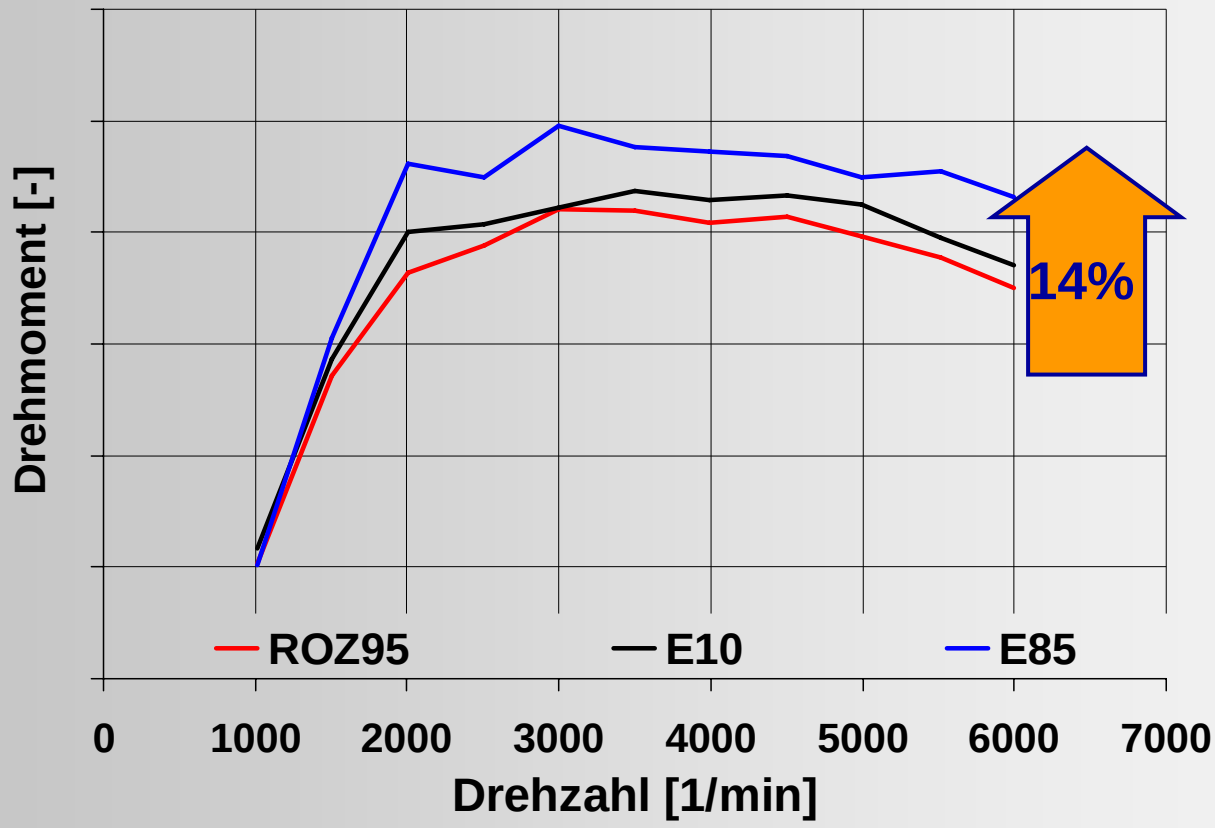
⇨Increase of Engine Torque by the use of Ethanol



As a result of this higher engine torque Downsizing, Downspeeding are strategies to decrease the fuel consumption.

Outlook

- Cold Start with an adopted E85-fuel (DVPE) is uncritical.
- HC-emissions increase during the -7°C cold start. Therefore an adopted cold start strategy and a improvement of engine application is necessary.
- The vehicle out CO2-emission in the New European Driving Cycle can be reduced for up to 5% by the use of E85.
- Further potential for modern engine concepts.

Summary

Thank you for your attention!

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